DEFENSE THREAT REDUCTION AGENCY
16.A Small Business Technology Transfer (STTR)
Proposal Submission Instructions

The approved FY16.A topics solicited for in the Defense Threat Reduction Agency (DTRA) Small Business Technology Transfer (STTR) Program are listed below. Offerors responding to this Solicitation must follow all general instructions provided in the Department of Defense (DoD) Program Solicitation. Specific DTRA requirements that add to or deviate from the DoD Program Solicitation instructions are provided below with references to the appropriate section of the DoD Solicitation.

The DTRA STTR Program addresses development of innovative ideas against DTRA's mission to counter Weapons of Mass Destruction (Chemical, Biological, Radiological and Nuclear) threats and that are consistent with the purpose of the STTR Program – i.e., to stimulate a partnership of ideas and technologies between innovative small business concerns (SBCs) and research institutions through Federally-funded R/R&D to addresses DTRA needs.

For technical questions about specific topics during the Pre-Solicitation period (11 December 2015 to 10 January 2016), contact the DTRA Technical Point of Contact (TPOC) for that specific topic. To obtain answers to technical questions during the formal Solicitation period, visit https://sbir.defensebusiness.org/. For general inquiries or problems with the electronic submission, contact the DoD Help Desk 1-800-348-0787 (Monday through Friday, 9:00 a.m. to 6:00 p.m. Specific questions pertaining to the DTRA STTR Program should be submitted to:

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PHASE I PROPOSAL GUIDELINES

The TPOC leads the evaluation process of all proposals submitted for their topics. In this process, DTRA will make a determination as to whether the proposal is relevant to the topic solicited. Only relevant proposals will be evaluated against further criteria. DTRA will evaluate Phase I proposals using the criteria specified in section 6.0 of the DoD STTR Program Solicitation during the review and evaluation process. The criteria will be in descending order of importance with technical merit being the most important, followed by qualifications, and followed by the commercialization potential. With other factors being equal, cost of the proposal may be included in the evaluation. DTRA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded. Phase I contracts are limited to a maximum of $150,000 over a period not to exceed seven months. DTRA anticipates funding one or possibly two STTR Phase I contracts to small businesses with their research institution partner for each topic.

The DoD SBIR/STTR Proposal Submission system (https://sbir.defensebusiness.org/) provides instruction and a tutorial for preparation and submission of your proposal. Refer to section 5.0 at the front of this solicitation for detailed instructions and the Phase I proposal format. You must include a Company Commercialization Report (CCR) as part of each proposal you submit. If you have not updated your commercialization information in the past year, or need to review a copy of your report, visit the DoD SBIR/STTR Proposal Submission site. Please note that improper handling of the

Commercialization Report may have a direct impact on the review and evaluation of the proposal (refer to section 5.4.e of the DoD Solicitation).

Proposals addressing the topics will be accepted for consideration if received no later than the specified closing hour and date in the solicitation – **6:00 a.m. ET, Wednesday, 17 February 2016.** The Agency requires your entire proposal to be submitted electronically through the DoD SBIR/STTR Proposal Submission Web site (https://sbir.defensebusiness.org/). A hardcopy is NOT required and will not be accepted. Hand or electronic signature on the proposal is also NOT required.

DTRA has established a **20-page limitation** for Technical Volumes submitted in response to its topics. This does not include the Proposal Cover Sheets (pages 1 and 2, added electronically by the DoD submission site), the Cost Volume, or the Company Commercialization Report. The Technical Volume includes, but is not limited to: table of contents, pages left blank, references and letters of support, appendices, key personnel biographical information, and all attachments. DTRA requires that small businesses complete the Cost Volume form on the DoD Submission site versus submitting it within the body of the uploaded volume. Proposals are required to be submitted in Portable Document Format (PDF), and it is the responsibility of submitters to ensure any PDF conversion is accurate and does not cause the Technical Volume portion of the proposal to exceed the 20-page limit. **Any pages submitted beyond the 20-page limit, will not be read or evaluated.** If you experience problems uploading a proposal, call the DoD Help Desk at 1-800-348-0787, from 9:00 a.m. to 6:00 p.m. Eastern Time, Monday through Friday.

Companies should plan carefully for research involving animal or human subjects, biological agents, etc. (see sections 4.7 - 4.9). The few months available for a Phase I effort may preclude plans including these elements, unless coordinated before a contract is awarded.

If the offeror proposes to use a foreign national(s) – refer to sections 3.5 and 5.4.c(8) in the DoD Solicitation for definitions and reporting requirements. Please ensure no Privacy Act information is included in this submittal.

If a small business concern receives an STTR award they must negotiate a written agreement between the small business and their selected research institution that allocates intellectual property rights and rights to carry out follow-on research, development, or commercialization (section 10).

PHASE II PROPOSAL GUIDELINES

Small business concerns awarded a Phase I contract will be permitted to submit a Phase II proposal for evaluation and potential award selection. The Phase II proposals must be submitted NLT 30 days BEFORE the end of the 7 month Phase I effort.

All STTR Phase II awards made on topics from solicitations prior to FY 13 will be conducted in accordance with the procedures specified in those solicitations.

DTRA is not responsible for any money expended by the proposer prior to contract award.

All Phase I awardees may apply for a Phase II award for their topic.

Phase II proposals will be reviewed for overall merit based upon the criteria in section 8.0 of this solicitation and will be similar to the Phase I process. The TPOC leads the evaluation process of all proposals submitted in their topics. DTRA will evaluate Phase II proposals using the criteria specified in section 8.0 of the DoD STTR Program Solicitation during the review and evaluation process. The criteria will be in descending order of importance with technical merit being the most important, followed by contractor's qualifications, and followed by the commercialization potential. With other factors being equal, cost of the proposal may be included in the evaluation. DTRA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

STTR Phase II proposals have 4 sections: Proposal Cover Sheets, Technical Volume, Cost Volume and Company Commercialization Report. As instructed in section 5.4.e of the DoD STTR Program Solicitation, the CCR is generated by the submission website based on information provided by you through the "Company Commercialization Report" tool.

PUBLIC RELEASE OF AWARD INFORMATION

If your proposal is selected for award, the technical abstract and discussion of anticipated benefits will be publicly released via the Internet. Therefore, do not include proprietary or classified information in these sections. For examples of past publicly released DoD SBIR/STTR Phase I and II awards, visit https://sbir.defensebusiness.org/resources.

TECHNICAL ASSISTANCE

In accordance with the Small Business Act (15 U.S.C. 632), DTRA will authorize the recipient of a Phase I STTR award to purchase technical assistance services, such as access to a network of scientists and engineers engaged in a wide range of technologies, or access to technical and business literature available through on-line data bases, for the purpose of assisting such concerns as:

- making better technical decisions concerning such projects;
- solving technical problems which arise during the conduct of such projects;
- minimizing technical risks associated with such projects; and
- developing and commercializing new commercial products and processes resulting from such projects.

If you are interested in proposing use of a vendor for technical assistance, you must provide a cost breakdown in the Cost Volume under "Other Direct Costs (ODCs)" and provide a one-page description of the vendor you will use and the technical assistance you will receive. The proposed amount may not exceed $5,000 and the description should be included as the LAST page of the Technical Volume. This description will not count against the 20-page limit and will NOT be evaluated. Approval of technical assistance is not guaranteed and is subject to review of the contracting officer.

DECISION AND NOTIFICATION

DTRA has a single Evaluation Authority (EA) for all proposals received under this solicitation. The EA either selects or rejects Phase I and Phase II proposals based upon the results of the review and evaluation process plus other considerations including limitation of funds, and investment balance across all the DTRA topics in the solicitation. To provide this balance, a lower rated proposal in one topic could be selected over a higher rated proposal in a different topic. DTRA reserves the right to select all, some, or none of the proposals in a particular topic.

Following the EA decision, DTRA STTR will release notification e-mails for each accepted or rejected offer. E-mails will be sent to the addresses provided for the Principal Investigator and Corporate Official. Offerors may request a debriefing of the evaluation of their not selected proposal and should submit this request via email to dtra.belvoir.J9.mbx.sbir@mail.mil and include “STTR 16.A Topic XX Debriefing Request” in the subject line. Debriefings are provided to help improve the offeror’s potential response to future solicitations. Debriefings do not represent an opportunity to revise or rebut the EA decision.

For selected offers, DTRA will initiate contracting actions which, if successfully completed, will result in contract award. DTRA Phase I awards are issued as fixed-price purchase orders with a maximum period of performance of seven-months. DTRA may complete Phase I awards without additional negotiations by the contracting officer or opportunity for revision for proposals that are reasonable and complete.

DTRA STTR 16.A Topic Index

DTRA STTR 16.A Topic Descriptions

DTRA16A-001 TITLE: Rapid Development of Weapon Payloads via Additive Manufacturing

TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Adapt emerging additive manufacturing techniques, e.g., so-called 3-D Printing, for use with both traditional (e.g., high explosives) and emerging (e.g., reactive structural materials) energetic material systems, develop and demonstrate capability using these additive manufacturing techniques to rapidly and/or remotely fabricate energetic material payloads and munitions.

DESCRIPTION: The Defense Threat Reduction Agency (DTRA) desires to enhance the effectiveness of conventional high-explosive munitions across a broad range of ordinance platforms, for use against an array of potential targets ranging from chemical and biological threat materials to WMD targets in deeply buried/hardened tunnels and multi-chamber bunkers. In this STTR, the approach is to explore use of emerging Additive Manufacturing (AM) techniques for improving the complexity, reducing the manufacturing cycle time, and increasing manufacturing flexibility, to provide more effective munition warheads. While some techniques for additive manufacturing (AM) are long established state-of-art fabrication technologies, the AM field has more recently been undergoing rapid innovation, with new capabilities in particular for so-called 3D printing; these have resulted in very high quality-low cost AM capabilities. AM is now a rapidly developing materials processing technology which could hold substantial promise for making components of advanced munitions, including the energetic materials that go into these systems. These AM approaches offer new possibilities in design complexity, in speed of manufacture, and in providing capability of remote or distributed manufacture For instance, bulk metal parts and components can be replaced with those using reactive structural materials for penetrators, liners, and other components of munitions. Reactive structural materials of interest that could be fabricated in new, more complex ways through AM techniques include composites capable of highly exothermic reactions, such as thermites, intermetallic, and metal-metalloid systems. Currently, use of organic binders and other low-density polymer components often needs to be minimized to maintain structural strength and density of the prepared components. AM fabrication techniques could help to further reduce or eliminate need for such components from complex munition designs. Recently, enhancements to weapon energy-density have been achieved through use of reactive composites prepared using individual material components, sometimes mixed on the submicron-scale. These applications may be amenable to further enhancement, to more complex design, and to more rapid manufacture if they can be adapted to emerging AM fabrication technologies. The focus of this topic is the adaptation and enhancement of emerging AM techniques and capabilities in 3-D printing to enhance the efficacy of weapons and munitions through new ability for more complex warhead designs, more rapid prototyping and production, and ability to remotely manufacture integrated weapon systems using AM technologies.

PHASE I: Phase I will explore one particular AM methodology suitable for preparation of inorganic reactive materials, namely so-called 3-D printing technology. Identify and explore the various 3-D printing techniques and identify candidate 3-D printing technology suitable for manufacture of structural components from inorganic reactive materials. This study will include exploration of modifications or improvements needed to address the safety and unique material properties of the energetic materials to be processed. A feasibility demonstration of safely preparing a 3-D printed part or component with at least one reactive material is desired. The material must remain reactive following the 3-D printing. Phase I deliverable is a final report documenting the effort and results, and should include a recommendation for AM techniques to be further investigated and developed in Phase II. It is understood that the analytical and experimental efforts will be conducted in full partnership between a small business and a university or other eligible collaborator, with details of the work breakdown at the discretion of the partners.

PHASE II: Expand the scope of the Phase I exploration to study AM technologies suitable for manufacture of warhead components from starting organic energetic materials such as high explosives and oxidizers, technologies suitable for manufacture of warhead components from inorganic reactive structural materials, and technologies suitable for manufacture of warhead components from new materials which are composite organic-inorganic energetic materials. Working with DTRA, design and fabricate, using suitable AM technologies, a conceptual warhead with suitable design complexity, to include both a high explosive payload component and a reactive reactive structural material component that also acts as the warhead case. Measure and characterize the sensitivity and energetic performance of sample materials fabricated using these AM techniques, and compare to energetic performance and sensitivity of similar materials fabricated by traditional techniques. Demonstrate fabrication feasibility and scalability by fabricating and delivery to DTRA three test items of sufficient size and mass for testing at the DTRA Chestnut test range (detailed drawings for these test cases will be provided to performer by DTRA; rough size of these test items is 5.5 inch inner-diameter cylinder, wall thickness determined by material density, case weight approximately 12 pounds mass, length approximately 9 inches.) Phase II deliverables include the 3 test cases and a detailed final report describing the testing implementation and results, and scale-up observations. The report must also contain detailed procedures for casing material synthesis/fabrication and scaling.

PHASE III DUAL USE APPLICATIONS: A successful Phase II demonstration will motivate several commercial applications, including the development of new explosive devices for mining and drilling operations. Additional commercial applications for these materials may be as energetic shaped charge liners for use in well stimulation, bore case perforation, and mining applications. A successful Phase II demonstration will encourage DTRA and Department of Defense use across a wide range of weapon platforms to improve weapon performance and utility.

REFERENCES:
1) http://wohlersassociates.com/history2014.pdf provides an extensive history of significant additive manufacturing milestones.

2) Committee F42 on Additive Manufacturing Technologies of the American Society for Testing and Materials (ASTM) Active Standard F2792-12a "Standard Terminology for Additive Manufacturing Technologies"

3) Deckard, Method and apparatus for producing parts by selective sintering, US Patent 4,863,538, September 5, 1989

4) Hull, Apparatus for production of three-dimensional objects by stereolithography, US Patent 4,575,330, March 11, 1986

5) David, L. B., Ming, C. L., & David, W. R. (2009). NSF Workshop—Roadmap for Additive Manufacturing: Identifying the Future of Freeform Processing. The University of Texas at Austin, Austin, TX, Technical Report.

6) Bourell, D. L., et al. "A brief history of additive manufacturing and the 2009 roadmap for additive manufacturing: looking back and looking ahead." Proceedings of RapidTech (2009): 24-25

7) Hartke, K., AFRL-RX-WP-TR-2011-4322, MANUFACTURING TECHNOLOGY SUPPORT (MATES) Task Order 0021: Air Force Technology and Industrial Base Research, and Analysis, Subtask Order 06: Direct Digital Manufacturing, Final Report, AUGUST 2011

8) Waller, J., Saulsberry, R., Parker, B., Hodges, K., Burke, E., & Taminger, K. (2014). Summary of NDE of Additive Manufacturing Efforts in NASA. available at http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20140009937.pdf

9) Jakus, A. E., Fredenberg, D. A., McCoy, T., Thadhani, N., & Cochran, J. K. (2012, March). Dynamic deformation and fragmentation response of maraging steel linear cellular alloy. In SHOCK COMPRESSION OF CONDENSED MATTER-2011: Proceedings of the Conference of the American Physical Society Topical Group on Shock

10) Compression of Condensed Matter (Vol. 1426, No. 1, pp. 1363-1366). AIP Publishing.

11) Aydelotte, B., Braithwaite, C. H., McNesby, K., Benjamin, R., Thadhani, N., Williamson, D. M., & Trexler, M. (2012, March). A study of fragmentation in a Ni+ Al structural energetic material. In SHOCK COMPRESSION OF CONDENSED MATTER-2011: Proceedings of the Conference of the American Physical Society Topical Group on Shock Compression of Condensed Matter (Vol. 1426, No. 1, pp. 1097-1100). AIP Publishing.

12) Braithwaite, C. H., Collins, A. L., Aydelotte, B., McKenzie, F., Chiu, P. H., Thadhani, N., & Nesterenko, V. F. (2012). Advances in the study of novel energetic materials. Proc. 15th Semin. New Trends in Res. of Energetic Mater., Univ. of Pardubice, Czech Republic, 91-97.

13) Spadaccini, C., Additive Manufacturing and Architected Materials, DOE NNSA SSGF ANNUAL REVIEW (25 June 2014), http://www.krellinst.org/nnsassgf/conf/2014/pres/cspadaccini.pdf

14) http://www.navy.mil/submit/display.asp?story_id=86865; 2015 Naval Additive Manufacturing Technical Interchange (NAMTI) meeting at Naval Surface Warfare Center – Carderock.

15) Tappan, A. S., Cesarano III, J., & Stuecker, J. N. (2011). U.S. Patent No. 8,048,242. Washington, DC: U.S. Patent and Trademark Office.

16) Vine, T., Claridge, R., Jordan, T., Comfort, N., & Damerell, W. (2004). U.S. Patent Application 10/558,115. (US20060243151 A1 published Nov 2, 2006).

17) Fuchs, B. E., Zunino III, J. L., Schmidt, D. P., Stec III, D., & Petrock, A. M. (2013). U.S. Patent No. 8,573,123. Washington, DC: U.S. Patent and Trademark Office.

18) Ihnen, A., Lee, W., Fuchs, B., Petrock, A., Samuels, P., Stepanov, A., and Di Stasio, A., Inkjet Printing of Nanocomposite High-Explosive Materials for Direct Write Fuzing, 54th Fuze Conference, 13 May 2010, Kansas City, MO., http://www.dtic.mil/ndia/2010fuze/VAStec.pdf

19) Defense Acquisition University (DAU) Web Portal for Additive Manufacturing: https://acc.dau.mil/AM

KEYWORDS: Additive manufacturing, energetic materials, 3-D printing, reactive material, ordinance, explosive, casing

DTRA16A-002 TITLE: Self-fragmenting Structural Reactive Materials (SF-SRM) for High Combustion Efficiency

TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop, test and evaluate a scalable metal-based reactive structural material that will self-fragment to micron or sub-micron scale fuel particles when subjected to explosive shock loading, resulting in significantly enhanced metal combustion efficiency.

DESCRIPTION: The Defense Threat Reduction Agency (DTRA) desires to enhance the effectiveness of conventional high-explosive munitions across a broad range of ordinance platforms, for use against an array of potential targets ranging from chemical and biological threat materials to WMD targets in deeply buried/hardened tunnels and multi-chamber bunkers. While new explosive materials may yield improved blast loading, much more significantly enhanced blast effects are potentially achievable by taking advantage of reactive structure used as the ordinance casing. The shock from a detonation yields high stresses, pressures, and temperatures to the casing materials, which causes rapid fragmentation of the case to occur. If the case is made of a combustible structural material such as Aluminum, sufficiently rapid combustion of these fragments can significantly enhance the blast. The high combustion enthalpy of metal fuel casing materials can substantially contribute to the work being done behind the initial blast wave, yielding sustained overpressure and improved thermal loadings.[1] It has been shown that various metal fuels and reactive material compositions can have a substantial effect on the delivered blast loading [2]. However, if the initial shock does not break the bulk of the casing material into sufficiently small fragments, or the metal particles are cooled quickly in the surrounding air, the metal oxidation efficiency will be low, which will result in lower delivered performance. The overall efficacy of these enhanced blast casing materials is largely dependent upon providing sufficiently short metal combustion residence times. While casing geometry can play a role in enhanced case fragmentation, the objective of this study is to develop a new material that inherently “self-fragments” into the required small metal particle size distribution, rather than developing a new ordinance design technology or platform.

This STTR seeks the development, testing and evaluation of innovative reactive structural casing materials that will, upon exposure to explosive shock loading, induce the in situ formation of micron-scale or submicron-scale metal fuel particles/droplets from the bulk of the casing, which particles will then combust extremely rapidly to significantly enhance blast effects. The research must demonstrate a feasible method of rapid fine-particle-fragmentation of the bulk casing material’s metallic component(s) and show its delivered performance in controlled enhanced blast experiments. The casing material may be multicomponent in nature (i.e., composite), but must be at least 70 weight percent metallic (typically Aluminum, but not required to be Aluminum). Additionally, the casing material must be such that it can be used to fabricate typical DoD munition cases using state-of-art fabrication processes, for example, such that cases can be formed through pressing from a powdered state, with nominal starting particle size no smaller than 1 micron and no larger than 80 microns. The proposed casing material(s) must also show feasible scalability, and acceptable sensitivity and ageing properties, for future DTRA adoption across a broad range of ordinance platforms.

PHASE I: Develop by analysis a list of candidate Self-fragmenting Structural Reactive Materials (SF-SRM). Perform initial characterization for one candidate metal-based SF-SRM (e.g., using powders) for use as an ordinance casing material. The consolidated material must be shown to be safe to handle, including low sensitivity to electrostatic shock, friction, and drop weight impact. In the final configuration the material. Perform initial combustion characterization of this SF-SRM, at high heating rates relevant to the intended use in munition applications, using laboratory techniques (e.g. via. laser heating). Perform initial evaluation of the ability of this candidate SF-SRM for rapid self-fragmentation and dispersion of fine fragments. Phase I deliverable is a final report documenting the effort and results, and should include a recommendation for casing material(s) to be further investigated and developed in Phase II. It is understood that the analytical and experimental efforts will be conducted in full partnership between a small business and a university or other eligible collaborator, with details of the work breakdown at the discretion of the partners.

PHASE II: From the list of candidate SF-SRM developed in Phase I, down-select to one to two (depending on resource availability) candidate casing materials for further development and evaluation. For these materials, demonstrate that the consolidated materials are sufficiently resistant to oxidation by exposure to air and moisture (to provide long shelf-life). Demonstrate the proposed casing material(s) in small scale explosive shock experiments. For the purposes of intended application of this work, these experiments must have a minimum high explosive charge of 10 grams and a case-mass-to-fill-mass-ratio ratio of 3:1, i.e., relevant to current DoD penetrating munitions. The experiments must be able to quantify initial blast loadings, sustained overpressure, and delivered casing combustion efficiency. The spatial and spectral breakout characteristics of the casing material(s) must also be investigated. All experiments must be compared to a baseline aluminum casing of the same geometry. The scalability of the highest performing casing material must also be shown in respect to starting material manufacturing and application. As part of this process, a larger explosive shock experiment must be performed and analyzed with a minimum explosive charge of 100 grams and at the same case-mass-to-fill-mass-ratio ratio. Final scale-up feasibility shall be to manufacture and deliver to DTRA three test cases of sufficient size and mass for testing at the DTRA Chestnut test range (detailed drawings for these test cases will be provided to performer by DTRA; rough size of these test items is 5.5 inch inner-diameter cylinder, wall thickness determined by material density, case weight approximately 12 pounds mass, length approximately 9 inches.) Phase II deliverables include the 3 test cases and a detailed final report describing the testing implementation and results, and scale-up observations. The report must also contain detailed procedures for casing material synthesis/fabrication and scaling.

PHASE III DUAL USE APPLICATIONS: A successful Phase II demonstration will motivate several commercial applications, including the development of new explosive devices for mining and drilling operations. Additional commercial applications for these materials may be as metallized fuels in solid rocket propellants (e.g., satellite booster motors) and pyrotechnics.
A successful Phase II demonstration will motivate encourage DTRA and Department of Defense adoption of the technology use across a wide range of weapon platforms that house conventional explosive ordinance packages to improve weapon performance and utility. Again, these materials may also be used as metallized fuels in future solid rocket propellants (e.g., tactical missiles) and pyrotechnics.

REFERENCES:
1. Dearden, P., New blast weapons. J R Army Med Corps, 2001. 147(1): p. 80-6.

2. Clemenson, M.D., et al., Explosive Initiation of Various Forms of Ti/2B Reactive Materials. Propellants, Explosives, Pyrotechnics, 2014. 39(3): p. 454-462.

KEYWORDS: enhanced blast, thermobaric, reactive material, energetic material, ordinance, explosive, casing

DTRA16A-003 TITLE: Innovative Mitigation of Radiation Effects in Advanced Technology Nodes

TECHNOLOGY AREA(S): Electronics, Space Platforms

OBJECTIVE: Develop generic or automated radiation hardening tools software and / or hardware tools to advance the state-of-the-art of Rad Hard by Design (RHBD) techniques in advanced technology nodes.

DESCRIPTION: There is significant value in getting data as early as possible on the radiation response of new and advanced technologies nodes. Frequently, however, the “non-standard” structures required to support radiation response are not present in standard test chip patterns or scribe-line electrical test structures. Development of generic radiation effects characterization pcm test are needed to afford an early look at the detailed radiation response of the technology, enabling first-pass success “harden-by design” approaches for advanced technology nodes (features <90nm for RFCMOS, SiGe, and Heterogeneous Bipolar technology (HBT) and <45nm for digital CMOS). There is also a critical need for automated radiation hardening tools to advance the state-of-the-art Rad Hard by Design (RHBD) techniques in advanced technology nodes. Development of such tools will result in significant savings in the development of advanced radiation hardened circuits for critical DoD applications.

PHASE I: For generic characterization tools that will enable early radiation response: Demonstrate an initial evaluation of process and device sensitivities (using foundry electrical simulation models) to enable early access of radiation response. The outcome of the Phase I would include 1) identification of a specific list of the electrical structures and their geometries, and 2) a specific list of what electrical parameters (vs radiation exposure and bias) to be characterized in a Phase II effort. For the development of automated software tool that will advance the radiation by design (RHBD) techniques, the Phase I should focus on developing models of charge generation, charge collection, and circuit response using existing data from literature and computer models (ex. TCAD, LSPICE). The result of this Phase I should be a description of simulation or modeling results that will advance RHBD techniques.

PHASE II: For generic characterization tool that will enable early radiation response: Demonstrate the technology to develop a generic characterization process for early access of radiation response of sample test structures. The technology demonstration in Phase II will include 1) a gds layout file of all the associated test devices and circuits, 2) build test silicon, 3) generate accompanying documentation for those structures and circuits, and 4) design and execute a test plan of what parameters (vs radiation exposure and bias conditions). For the development of automated codes that will advance RHBD techniques, the Phase II effort should develop 1) device and or circuit models with RHBD layout constraints to mitigate single event effects and 2) validate the radiation charge generation, charge collection, and circuit response models developed in Phase I. The Phase II should also include preliminary design, fabrication, and radiation testing of simple test structures needed to validate the radiation induced SEE response models and RHBD mitigation schemes developed in Phase I and II. The RHBD mitigation schemes should include either a memory, logic, I/O, Phase Lock Loops, Delay Lock Loops, or analogy mixed signal circuits. Industry and government partners for Phase III must be identified along with demonstration of their support. A roadmap that takes the program through Phase III must be part of the final delivery for Phase II.

PHASE III DUAL USE APPLICATIONS: For generic characterization tool that will enable early radiation response, the final outcome is to provide electric and layout parameters necessary to support design of these products to enable the space and defense community to execute first-pass-success radiation-tolerant or radiation-hardened designs. This Phase III should include initial silicon fabrication, and an exhaustive electrical characterization (vs radiation exposure) of the silicon. Parametric shifts as a function of radiation exposure and bias should be characterized, and electrical design parameters shall be made available to the design community. For development of software codes to advance RHBD, the Phase III should include development of macros for mitigation of radiation effects in common electronic circuits and development of software and / or hardware architecture. This Phase should also automate the implementation of the circuit macros in software and / or hardware architecture developed in Phase II and makes the technology available to USERS developing RHBD circuit designs.

REFERENCES:
1. Kai, K., et al. "Channel dopant profile and Leff extraction of deep submicron MOSFETs by Inverse Modeling." Simulation of Semiconductor Processes and Devices, 1996. SISPAD 96. 1996 International Conference on IEEE, 1996.

2. Groeseneken, G., Maes, H. E., Beltran, N., & De Keersmaecker, R. F. (1984). A reliable approach to charge-pumping measurements in MOS transistors. Electron Devices, IEEE transactions on, 31(1), 42-53.

3. C. Jan et al, IEDM 2012 Tech Dig. pp 44-47, 2012

4. A. T. Kelly, et al. “Kernel-Based Circuit Partition Approach to Mitigate Combinational Logic Soft Errors”, IEEE Trans. On Nuclear Science, vol 61, no.6, pp.3274-3281, Dec. 2014.

KEYWORDS: Materials/Processes, Nano-technology, Nuclear Technologies, Single-Event Effect, Total Ionization Dose, Radiation Hardened Microelectronics

DTRA16A-004 TITLE: Compact Laser Drivers for Photoconductive Semiconductor Switches

TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: The objective is to develop low-cost, compact, fast-rise-time, low-jitter pulse charging and laser trigger systems for photoconductive semiconductor switches (PCSSs) (ref. 1-15) to enable their application to many DoD applications including Electromagnetic Pulse (EMP) (ref. 6) and High Power Microwave (HPM) (ref. 7) systems. Cost of the technology will be a driver for the feasibility of scaling to large arrays and to multiple pulsed power system applications.

DESCRIPTION: Gallium arsenide (GaAs) PCSS technology has been demonstrated with switching and timing jitter times under 1 nanosecond (ns) for voltages up to 100 kV (ref. 1-2). The low timing jitter enables the development of planar or phased arrays of modular EMP or HPM sources. Each module is anticipated to fit within a 1 meter cube, most of which is filled by the radiating antenna structure. To enable the development of arrays of high voltage pulsers based on PCSS technology, it is preferable to have charging/triggering systems that are fully electrically isolated. Existing GaAs PCSS cannot sustain DC voltages without breaking down. This requires that the switched storage capacitors must be pulse charged in a few microseconds to ±50 kV or 100 kV total. For an EMP test capability and many pulsed power applications, a shot rate of a few per hour is adequate, but higher shot rates would be needed for many HPM applications. A compact, battery-powered pulse charging system is desired for an EMP test capability to avoid the requirement for power cables that will cause loading and reflections on the antenna array. The pulse charging system can be based on spark gaps, MOSFETs, inductive technologies, or any other approach that can achieve the needed size, efficiency, and reliability. Triggering a GaAs PCSS requires ~10-100 microJoules (μJ) of 840-880 nanometer (nm) laser energy per cm2 of switch area delivered in ~1 ns. Many laser technologies can achieve this, but rendering the system compact and low cost will require research and innovation. For an initial EMP demonstration it will take ~3 cm2 of switch area to conduct 1 kA with at an initial voltage of 100 kV. The timing jitter of the laser trigger system must be <0.3 ns 1σ. For maximum scalability and safety for an EMP array, it is desirable to have the laser trigger system integrated into each module. However, a single laser driving multiple fiber optic cables with adjustable relative timing may be adequate for an initial demonstration.

PHASE I: The minimum objective for Phase I will be the design of compact pulse charging and laser triggering systems adequate to drive an EMP array module based on GaAs PCSS technology. The pulse charging system should be capable of charging a 1 nFd capacitor to 100 kV in <10 μS. The laser trigger system should be capable of delivering 300 μJ of 840-880 nm light uniformly to a 1.5 cm by 2 cm switch area with <0.3 ns 1 σ timing jitter. Bread boarding and demonstration of any high risk components or the complete systems would be preferable.

PHASE II: For Phase II the objective will be to fabricate and demonstrate pulse charging and laser triggering systems adequate for 9-module EMP array based on GaAs PCSS. Each module should fit within a 1 meter cube and have an initial pulse charge of 100 kV across the PCSS. The test objective is to demonstrate that the timing jitter of the individual modules is <0.3 ns 1σ.

PHASE III DUAL USE APPLICATIONS: For Phase III the initial application is anticipated to be a transportable EMP test array that can be easily configured for either vertical or horizontal polarization. The contractor will have to work with DoD and civilian agencies to customize the test capability for various mission critical system and infrastructure applications. Other applications of the PCSS triggering systems are expected to include future large-scale pulsed power systems requiring many thousands of high reliability spark gap triggering systems (ref. 2-4). The contractor will have to work with the National Nuclear Security Administration to define the detailed requirements.

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